Chapter 3

Airport and Airspace Capacity

The most direct way to bring about an increase in capacity is to improve the number of hourly operations at airports. Two initiatives that are directly aimed at that end are discussed in this section. One is to develop and implement capacity-enhancing approach procedures. The other is to sponsor airspace planning projects that make use of national and local expertise to improve the operations of specific airports and the surrounding airspace with an emphasis on making use of tools and techniques that are available in the near term.

3.1 Instrument Approach Procedures

In FY90, more than half of all delays were attributed to adverse weather conditions. These delays are in part the result of instrument approach procedures that are much more restrictive than the visual procedures in effect during better weather conditions. Much of the delay could be eliminated if the approach procedures used during IFR operations were closer to those observed during VFR operations.

During the past few years the FAA has developed new, capacity-enhancing approach procedures. In most cases, these are multiple approach procedures aimed at increasing the number of airports and runway combinations that can be used simultaneously, either independently or dependently, in less than visual approach conditions.[1] Some of these procedures require new technology or favorable research results in order to be implemented.

In FY90, more than half of all delays were attributed to adverse weather conditions.

Much of the delay could be eliminated if the approach procedures used during IFR operations were closer to those observed during VFR operations.

During the past few years the FAA has developed new, capacity-enhancing approach procedures.

1. In general, depending on the airport aircraft mix, single-runway IFR approach procedures allow about 26 arrivals per hour. Hence, two simultaneous approach streams, when operating independently of each other, double arrival capacity to 52 per hour. Three streams would allow 78 hourly arrivals, and so on. Such procedures are called "independent," because the aircraft in one stream do not interfere with arrivals in the other. Conversely, "dependent" procedures place restrictions between the aircraft streams, and, as a result, hourly capacity for dual dependent approaches is somewhere between 26 and 52 arrivals. In the case of dependent triple streams, the arrival capacity is somewhere between 52 and 78, depending on airport runway configurations.

The following sections present a brief description of the most promising approach concepts being developed, their estimated benefits, supporting technology, and candidate sites that might benefit from the new procedures. The busiest 100 airports are listed in Table 3-3 (described in Section 3.1.7), together with the new procedures that each can potentially use. Site specific analysis is needed to determine which procedures are most beneficial to each airport.

3.1.1 Wake Vortex Restrictions

Wake vortex hazards limit aircraft spacing and, hence, the arrival and departure capacities of airports. Better understanding of the properties of wake vortices and of aircraft response to them will result in reduced separation standards based on measured data. They will also allow the development of a wake vortex alerting system based on meteorological data. These developments would make possible reduced in-trail and departure separation and could possibly reduce the minimum spacing required between parallel runways for dependent parallel operations to as low as 1,000 feet.

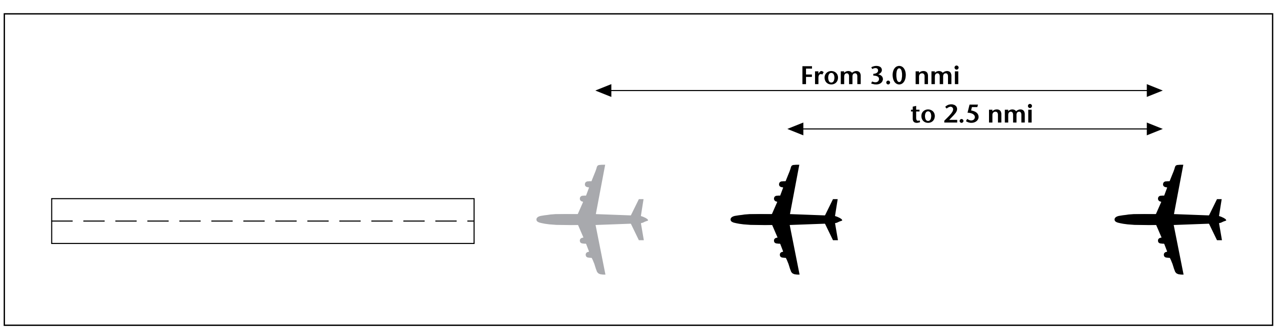
Recent efforts have helped improve the understanding of wake vortices by obtaining the wake vortex signatures of B-757 and B-767 aircraft and by measuring the characteristics of wake vortices under varying meteorological conditions. However, much more research is required before wake vortex associated spacing criteria can be revised.

Research is underway to better understand the properties of wake vorticies and how aircraft respond to them. This could possibly reduce the minimum separation required between parallel runways for dependent parallel operations to as low as 1,000 feet.

An improvement in the separation standard from 3.0 to 2.5 nmi on wet runways between certain classes of aircraft is currently undergoing demonstration. This may permit an increase of 3 to 5 additional arrivals per hour.

3.1.2 Improved Longitudinal Separation on Wet Runways

Air traffic control procedures include minimum longitudinal separation standards for aircraft in approach streams inside the final approach fix. The separation distances vary from 2.5 to 6 nmi, depending on the relative sizes of the leading and trailing aircraft. The minimum separations are intended to protect the trailing



Improved Longitudinal Spacing on Wet Runways

aircraft from the leading aircraft wake vortices. The minimum separation is also set to avoid situations in which the trailing aircraft lands before the leading aircraft has exited the runway. An improvement in the separation standard from 3.0 to 2.5 nmi on wet runways between certain classes of aircraft is currently undergoing demonstration at several airports. This improvement can potentially provide capacity gains of three to five arrivals per runway per hour. Most airports can benefit from the reduced separation standards.

3.1.3 Parallel Instrument Approaches

Currently, the separation between parallel runways must be at least 4,300 feet for simultaneous independent operations, and at least 2,500 feet for dependent parallel operations. The FAA is actively pursuing ways to reduce the runway spacing required for independent operations to as low as 2,500 feet and to increase the capacity of dependent runway configurations by reducing the required diagonal separation between aircraft on adjacent runways and the minimum separation distance between runways.

3.1.3.1 Independent Parallel Instrument Approaches Using a Precision Runway Monitor

The flexibility inherent in having two independent arrival streams provides a significant advantage relative to the dependent arrival case in which diagonal separations must be maintained. It can increase the number of operations per hour from about 26 to 52. These reductions are based on the use of the Precision Runway Monitor (PRM) (described in Section 4.1.3) in place of the existing terminal radar and displays.

During 1990, demonstrations conducted at Memphis (MEM) and Raleigh-Durham (RDU) showed that independent parallel approaches to runways 3,400 feet apart are possible using this new radar display technology. As a result, procedures to allow independent approaches to parallel runways 3,400 feet apart using the PRM will be published in 1991. The PRM will be developed into a production system to support these approaches. The first system will be commissioned at Raleigh-Durham in 1993, with four additional airports being added over the next two years.

During 1991, the FAA is conducting simulations at its Technical Center of independent approaches down to 3,000 feet of runway spacing using the new technology. These simulations will help demonstrate the feasibility of conducting simultaneous parallel approaches to runways with centerlines as close as 3,000 feet.

The FAA is actively pursuing ways to reduce the required spacing between parallel runways for conducting simultaneous independent instrument approaches from 4,300 feet to as low as 2,500 feet.

Demonstrations at MEM and RDU have shown that independent parallel approaches to runways 3,400 feet apart are possible using the Precision Runway Monitor (PRM).

Airports that might benefit from PRM implementation are listed in Table 3-1, segregated by runway separation. Included are the airports selected to receive the first five systems. The other airports are preliminary candidates only. Some of the candidate airports are currently able to operate independent parallel approaches. Therefore, PRM use would apply only if these airports stopped operating their largest-spaced runways (4,300 feet or more) and instead activated parallel runways that are closer to each other.

Twenty-one of the top 100 airports are preliminary candidates for the PRM.

Table 3-1. Candidate Airports for Independent Parallel Approaches Using the Precision Runway Monitor (PRM)

Runway Separation 3,400 to 4,299 feet[2]		Runway Separation 3,000 to 3,399 feet[2]	
Atlanta (ATL)[3]	Selected Site	Denver (DVX)[3]	
Baltimore (BWI)[3]	Selected Site	Harlingen (HRL)	
Detroit (DTW)		Long Beach (LGB)	
Fort Lauderdale (FLL)		Minneapolis-St. Paul (MSP)	Selected Site[5]
Memphis (MEM)	Selected Site	New York (JFK)	
Milwaukee (MKE)		Philadelphia (PHL)[3]	
Phoenix (PHX)		Portland (PDX)	
Pittsburgh (PIT)[4]			
Raleigh-Durham (RDU)	Selected Site	**Runway Separation 2,500 to 2,999 feet[2]**	
Salt Lake City (SLC)			
Tampa (TPA)		Columbus (CMH)	
		Dallas-Love Field (DAL)	
		Indianapolis (IND)	

2. Some of the airports in each spacing category may also have parallel runways with a different spacing category. However, airports are listed only one time under the spacing category most likely to be used, that is, runways with the largest spacing category.
3. Applicable upon construction of new runway(s).
4. Runways are 5,540 feet apart; a new runway is planned that will create a parallel set separated by 3,100 feet or 4,300 feet.
5. Runways at MSP are 3,380 feet apart; waiver is required for PRM.

3.1.3.2 Dependent Parallel Instrument Approaches

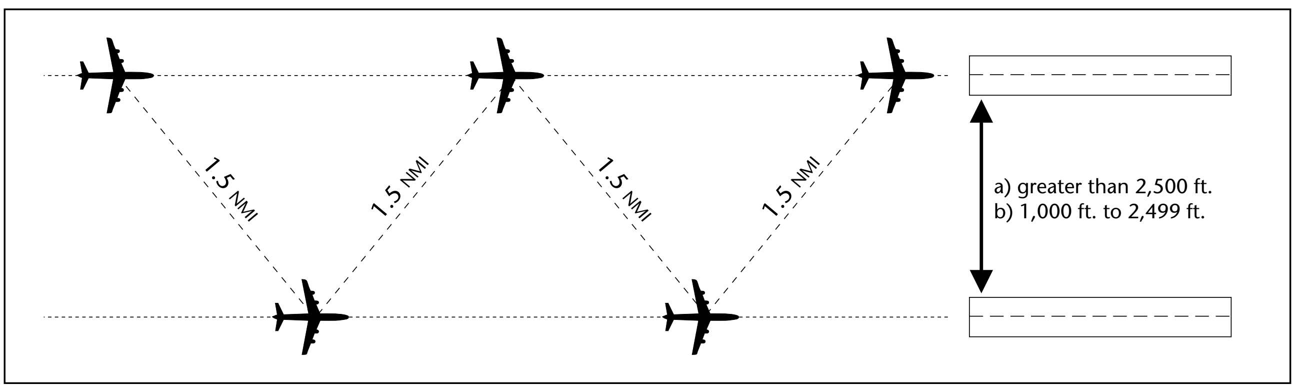
Existing rules for dependent IFR operations require that the spacing between parallel runways be at least 2,500 feet and the diagonal separation between aircraft on adjacent approaches be at least 2.0 nmi . The diagonal separation requirement places speed and in-trail restrictions on aircraft which reduce the arrival rate and operational flexibility of dependent parallel approaches, limiting the capacity increase associated with using two arrival streams.

Demonstration programs carried out in 1990 have shown that this diagonal separation can be safely changed to 1.5 nmi for runways at least 2,500 feet apart. This spacing would permit approximately four additional arrivals per hour compared to 2.0 nmi spacing. Procedure changes that will permit a 1.5 nmi diagonal separation for these runways will be issued in 1992.

A preliminary analysis has been made of the capacity gains that might be achieved by dependent operations on parallel runways 1,000 to 2,499 feet apart. The analysis has shown that arrival capacity increases of 46 to 65 percent are possible relative to single runway operations for diagonal separations between aircraft of 1.5 and 2.0 nmi respectively. Work is underway to validate these results and to determine whether such operations are feasible.

Demonstrations have shown that a reduction in diagonal separation from 2.0 to 1.5 nmi for runways at least 2,500 feet apart would permit approximately 4 additional arrivals per hour.

A preliminary analysis has shown that arrival capacity gains of 46% to 65% are possible relative to single runway operations for dependent operations on parallel runways 1,000 to 2,499 feet apart.

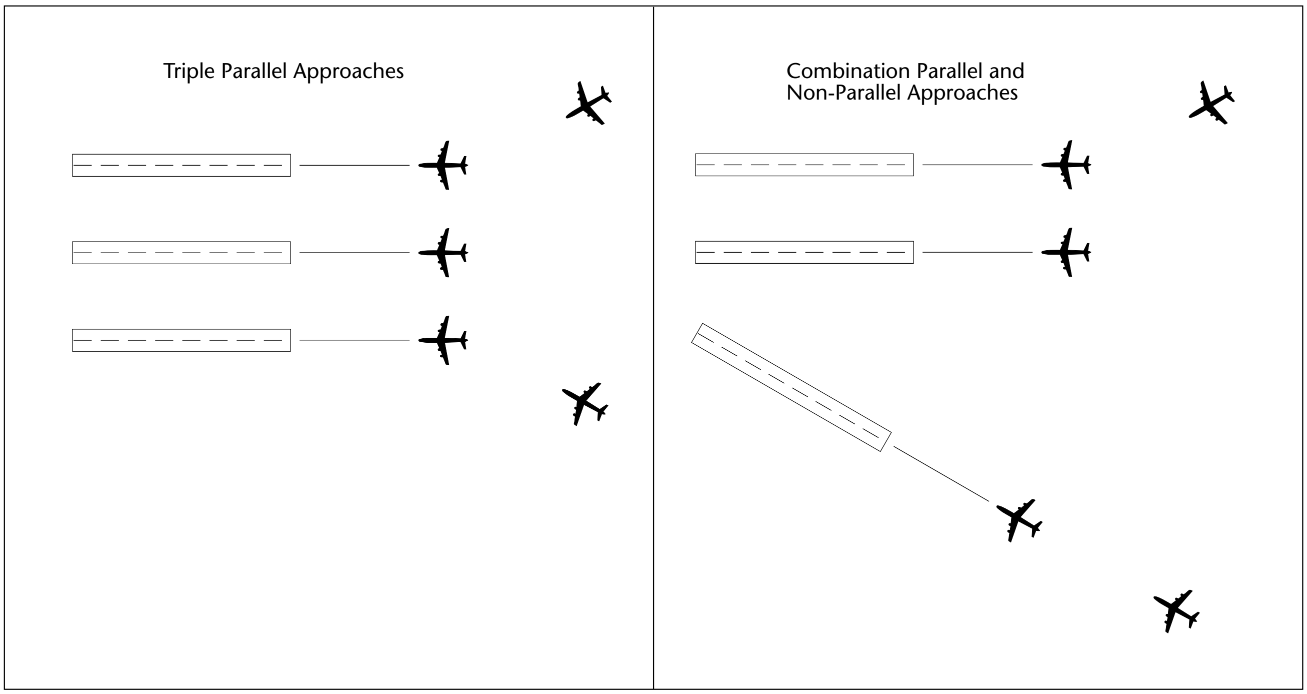


Dependent Parallel Instrument Approaches

3.1.4 Triple and Quadruple Instrument Approaches

The use of triple parallel approaches would result in a 50% increase in arrival capacity; quadruple approaches would provide a 100% increase in IFR conditions compared to dual independent approaches.

At some airports, combinations of independent parallel and converging instrument approaches could be used to implement triple or quadruple arrival streams with multiple departure streams. The primary applications of this concept involve airports that have independent arrival streams to parallel runways. For such airports, a favorably located additional parallel runway or a converging runway may be used for an additional arrival stream. The use of triple parallel approaches would result in a 50 percent increase in arrival capacity, whereas quadruple approaches would provide a 100 percent increase in IFR conditions compared to dual independent approaches.



Triple Instrument Approaches

Several airports, such as Atlanta, Dallas-Fort Worth, and Pittsburgh are planning on building parallel runways that will give them the capability of conducting triple and quadruple simultaneous parallel approaches. Dallas-Fort Worth has an existing configuration for triple approaches, as does Chicago O'Hare. Triple approaches using two parallel runways and one converging runway were approved at Dallas-Fort Worth in 1989. Preliminary analysis indicates that, of the top 100 airports, 15 are possible candidates for these type approaches.

Fifteen of the top 100 airports are possible candidates for triple or quadruple parallel approaches.

Work is currently underway to develop procedures and provide new technology that will optimize the use of these new runways. Simulations at the FAA Technical Center in 1988 and 1989 have resulted in the approval of triple and quadruple simultaneous parallel approaches at Dallas-Fort Worth. This approval is contingent upon construction of Runway 16L 5,000 feet from, and parallel to, Runway 17L, and Runway 16R 5,800 feet from, and parallel to, Runway 18R.

Simulations at the FAA Technical Center have resulted in the approval of triple and quadruple simultaneous parallel approaches at DFW.

The success of the 1988 and 1989 simulations has led to further simulations to develop generic procedures. This development process involves the use of the latest technology equipment such as Precision Runway Monitors and high resolution color displays for controllers. The goal is to develop generic procedures at the closest runway spacings while maintaining an equivalent or increased level of safety compared to today's operations.

3.1.5 Converging Approaches

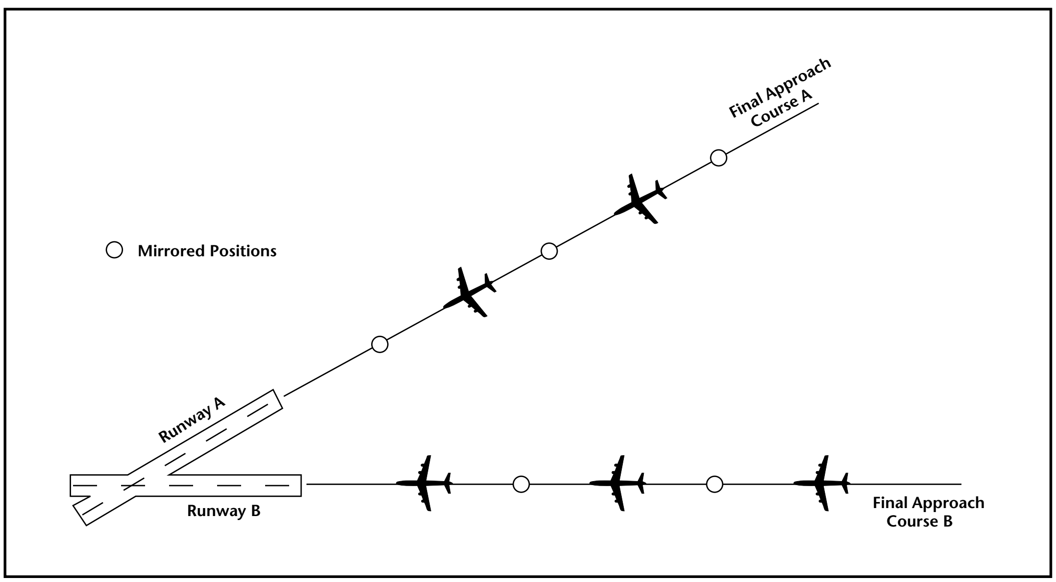
Converging runway approach improvements must take account of the wide variety of converging runway configurations that are in use. Numerous factors must be considered in designing approaches for a particular runway configuration. There is often a tradeoff between the minimum ceiling and visibility that can be achieved and the landing capacity, particularly in determining whether dependent or independent converging IFR approaches can be used. The FAA is actively pursuing ways to increase capacity for a wide variety of configurations while achieving the lowest possible landing minimums. At some airports it might be feasible to increase capacity at Category I landing minimums using technology that reduces the variability between successive operations. Procedural changes are being implemented that widen the range of weather conditions in which higher than previously achievable landing rates may be achieved for intersecting runways.

Technology that reduces the variability between successive operations is being considered to increase capacity at Category I landing minimums.

3.1.5.1 Dependent Converging Instrument Approaches

The landing minima for certain converging runway configurations are currently quite high due to the need to insure that aircraft on each approach are safely separated in the event of simultaneous missed approaches.[6] In return for the high minima, independent landing operations are possible. Typically, independent converging IFR approaches are feasible only when ceilings are above 600 feet depending upon runway geometry. As an alternative precision approach procedure, dependent operations could be conducted to much lower minima, usually down to Category I, expanding the period of time during which the runways can be used. However, in order to conduct these dependent operations efficiently, controllers need an automated method for ensuring that the aircraft on the different approaches remain safely separated. Without such a method, the separation of aircraft would be so large that little capacity would be gained.

Capacity increases of approximately 10 arrivals per hour are achievable using the Converging Runway Display Aid (CRDA) undergoing testing at STL.



Converging Instrument Approaches

A program is underway at St. Louis (STL) to evaluate dependent operations using a controller automation aid, the Converging Runway Display Aid (CRDA) (also called ghosting or mirror imaging and described in Section 4.1.2.1), to maintain aircraft

6. Simultaneous converging approaches are designed using the "TERPS + 3" criteria. This refers to the need for missed approach points to be separated by at least 3 nmi and for missed approach obstacle-free surfaces not to overlap.

stagger on approach. National implementation is planned for late 1992. It is estimated that capacity increases of approximately 10 arrivals per hour over single-runway arrival capacity are achievable with this procedure.

Airport surveys show that there is a high level of interest in the use of the CRDA at the twenty three airports listed in Table 3-2. Not all of these airports would necessarily show a capacity benefit however, because the surveys considered airport-specific needs that might not be directly related to capacity, an improved noise impact, for example.

The CRDA concept may also have applications under VFR. For example, it could be used at airports with intersecting runways that have insufficient length to allow hold short operations. Insufficient runway length between the threshold and the intersection with another runway can be ignored if arrivals are staggered such that one is clear of the intersection before the other crosses its respective threshold.

Twenty-three of the top 100 airports have shown an interest in the use of CRDA.

CRDA may also be used at airports with intersecting runways that have insufficient length to allow hold short operations.

Table 3-2. Candidate Airports for Dependent Approaches Using the Converging Runway Display Aid (CRDA)

Airports with a High Potential for Using the CRDA	
Baltimore (BWI)	Minneapolis-St. Paul (MSP)
Boston (BOS)	New York (JFK)
Chicago Midway (MDW)	New York La Guardia (LGA)
Chicago O'Hare (ORD)	Newark (EWR)
Cleveland (CLE)	Oakland (OAK)
Dallas-Fort Worth (DFW)	Philadelphia (PHL)
Dayton (DAY)	Pittsburgh (PIT)
Denver (DEN)	Portland (PDX)
Houston (HOU)	St. Louis (STL)
Memphis (MEM)	Washington Dulles (IAD)
Miami (MIA)	Windsor Locks (BDL)
Milwaukee (MKE)	

3.1.5.2 Simultaneous Operations on Intersecting Runways (SOIR)

The FAA is currently investigating the capacity ramifications of a number of proposed changes governing simultaneous operations on intersecting runways (SOIRs). Approved SOIRs, which include simultaneous takeoffs and landings and/or simultaneous landings, are authorized when a landing aircraft is able to and is instructed by the controller to hold short of the intersecting runway. Currently, SOIR are permitted only on dry runways. Demonstrations of simultaneous operations on intersecting wet runways (SOIWR) conducted at Boston Logan, Greater Pittsburgh, and Chicago O'Hare airports have pointed out the viability of standardizing these type operations. Procedural development is underway, and a national standard is expected in 1992.

Procedural development is underway for conducting simultaneous operations on intersecting wet runways.

Efforts are underway to re-structure the six SOIR groups. Sixty of the 100 airports would be affected by these changes.

Aircraft are classified into one of six SOIR groups which dictate the minimum landing distance that must be available in order for an aircraft in that group to be eligible to hold short. Proposed restructuring of these groups would more closely match the performance characteristics of aircraft by specifying minimum runway length requirements which differentiate between propeller and jet aircraft, between dry and wet runway conditions, and between different aircraft landing configurations. The runway length available on a hold short runway is currently measured from runway threshold to the nearest edge of the intersecting runway. Additional proposals would reduce this available runway length by requiring aircraft to hold short of Runway Safety Areas and Obstacle Free Zones bordering the intersecting runway.

Sixty of the top 100 airports currently conduct hold short operations and would be affected by these changes.The largest capacity benefits would be realized at airports where propeller aircraft use the hold short runway.

3.1.6. Expanded VFR Approach Procedures

Procedures are being developed for instrument approaches to STL and SFO for runways separated by less than 2,500 feet. They consist of an LDA approach to one parallel runway and an ILS approach to the adjacent parallel runway.

It is generally recognized that airport capacities in Instrument Meteorological Conditions (IMC) are well below those achieved in Visual Meteorological Conditions (VMC). However, once weather conditions fall below visual approach vectoring minima, even if conditions are still VFR, an airport whose parallel runways are separated by less than 2,500 feet generally has fewer options for conducting its multiple approaches. For example, San Francisco International (SFO) uses its Runways 28L and 28R about 85 percent of the time for simultaneous visual approaches. These runways are separated by 750 feet. Once the ceiling is less than 500 feet above the minimum vectoring altitude the airport is forced to go to a single runway operation because aircraft may no longer be vectored for visual approaches to both parallel runways.

A special solution to this problem has been developed and is in use at St. Louis Lambert Field (STL). (STL has parallel runways separated by 1,300 feet.) It involves the use of a Localizer Directional Aid (LDA) approach to one parallel runway and an ILS approach to the adjacent parallel runway. The localizer is offset from the runway centerline to provide increased separation far from the runway. These approaches are conducted simultaneously and utilize the procedures and equipment associated with simultaneous parallel approaches to runways separated by at least 4,300 feet; however, the STL procedure also requires the use of visual separation at or prior to the point where the separation between the final approach courses reaches 4,300 feet (the missed approach point). The minimums for the LDA approach is as low as a 1,200 foot ceiling and 4 miles of visibility.

A similar procedure has been proposed for San Francisco, and procedures are being developed with an anticipated implementation date of August 1992.

Point in space and other approach concepts applicable in marginal VFR conditions may be enhanced through the application of emerging technologies such as Traffic Alert and Collision Avoidance System (TCAS) (Section 4.1.5), Microwave Landing System (MLS) (Section 4.1.4), and the Converging Runway Display Aid (CRDA) (Section 4.1.2.1). These procedures are yet to be developed.

3.1.7 Approach Procedure Applicability at the Top 100 Airports

Table 3-3 shows the applicability of current and proposed procedures for the top 100 airports. The first column shows the current best hourly arrival capacity and the approach procedure utilized to achieve that capacity. The following columns show which of the proposed procedures discussed in the previous sections are applicable. It is important to bear in mind that this table is based on runway approach diagrams; factors such as noise, obstructions, and community concerns were not considered. Some airports may not be using their "current best" approach procedures. For these same reasons, the airports where the PRM might be applicable (Table 3-1) and where significant interest was shown for the CRDA (Table 3-2) are not identical to those shown in Table 3-3. In addition, the actual aircraft fleet mix at each airport was not used; the capacity figures are standard figures which are reasonable approximations of real capacity. The objective of the table is to provide initial information on the applicability of approach procedures being developed by the FAA. The estimated capacities should be used for comparison only.

An asterisk (*) indicates that the proposed approach procedure in the column in question is applicable at a given airport. A "p" indicates that the approach procedure may be applicable if and when proposed construction/extension plans actually take place. Some of this construction is in progress, while other is only at the proposal stage. A blank space indicates either that the runways do not support the proposed procedure, it is a borderline application, or there is not enough information to determine applicability. Finally, in order to highlight new approach procedures that would provide better capacity than any other procedures (current or proposed), an asterisk was replaced by a capacity number wherever the new procedure can provide higher capacity than any other. The number indicates the hourly arrival capacity of the procedure in question. It is easy to identify the most beneficial improvement by looking at the "New Approach Procedure" section in each row.

Table 3-3. Potential Siting of New IFR Approach Procedures and Their Associated IFR Arrival Capacity[1]

Airport Location	Airport Code	Current Best IFR Arrival Capacity (App Procedure)[2]	New Approach Procedures[3] Dependent Parallel	Independent Parallel	CRDA	TERPS+3	Triples
Agana (Guam)	NGM	26 (S)					
Albany	ALB	26 (S)			34		
Albuquerque	ABQ	26 (S)					
Anchorage	ANC	26 (S)				52	
Atlanta	ATL	52 (IP)	*	*p			63p
Austin (new airport)	AUS	52 (IP)					
Baltimore	BWI	26 (S)		52p	*		
Birmingham	BHM	26 (S)					
Boise	BOI	26 (S)					
Boston	BOS	26 (S)	36		*		
Buffalo	BUF	26 (S)			34		
Burbank	BUR	26 (S)			34		
Charleston	CHS	26 (S)			34		
Charlotte	CLT	52 (IP)			*	*	78p
Chicago	MDW	26 (S)					
Chicago	ORD	52 (IP)				*	78
Cleveland	CLE	26 (S)			34		
Colorado Springs	COS	26 (S)		*p	*	52	
Columbia	CAE	26 (S)			34		
Columbus	CMH	36 (DP)		*		52	
Dallas	DAL	36 (DP)		52			
Dallas-Fort Worth	DFW	52 (IP)				*	78p
Dayton	DAY	52 (IP)			*	*	
Denver (new airport)	DVX	52 (IP)	*				78
Des Moines	DSM	26 (S)			34		
Detroit	DTW	52 (IP)	*	*		*	63p
El Paso	ELP	26 (S)	*			52	
Fort Lauderdale	FLL	26 (S)		52	*		
Fort Myers	RSW	26 (S)		52p			
Grand Rapids	GRR	26 (S)		52p			
Greensboro	GSO	26 (S)		52p	*		
Greer	GSP	26 (S)		52p			
Harlingen	HRL	26 (S)		*	*	52	
Hilo	ITO	26 (S)			34		
Honolulu	HNL	52 (IP)			*		

Table 3-3. Potential Siting of New IFR Approach Procedures and Their Associated IFR Arrival Capacity[1] (continued)

Airport Location	Airport Code	Current Best IFR Arrival Capacity (App Procedure)[2]	New Approach Procedures[3] Dependent Parallel	Independent Parallel	CRDA	TERPS+3	Triples
Houston	HOU	26 (S)			34		
Houston	IAH	52 (IP)				*	78p
Indianapolis	IND	36 (DP)			*		
Islip	ISP	26 (S)			34		
Jacksonville	JAX	26 (S)				52	
Kahului	OGG	26 (S)			34		
Kailua-Kona	KOA	26 (S)					
Kansas City	MCI	26 (S)		*p		52	
Knoxville	TYS	26 (S)	36				
Las Vegas	LAS	26 (S)			34		
Lihue	LIH	26 (S)			*	52	
Little Rock	LIT	52 (IP)					
Long Beach	LGB	26 (S)	*	52	*		
Los Angeles	LAX	52 (IP)					
Louisville	SDF	26 (S)		52p	*		
Lubbock	LBB	26 (S)					
Memphis	MEM	36 (DP)		*	*	52	
Miami	MIA	52 (IP)			*	*	
Midland	MAF	26 (S)	*		*	52	
Milwaukee	MKE	26 (S)	*	*	*	52	
Minneapolis-St. Paul	MSP	36 (DP)		52	*		
Nashville	BNA	52 (IP)	*		*		
New Orleans	MSY	26 (S)		*p		52	
New York	JFK	36 (DP)		*	*	52	
New York	LGA	26 (S)			34		
Newark	EWR	26 (S)			*	52	
Norfolk	ORF	26 (S)			34		
Oakland	OAK	26 (S)	*			52	
Oklahoma City	OKC	52 (IP)				*	
Omaha	OMA	26 (S)	36		*		
Ontario	ONT	26 (S)					
Orlando	MCO	52 (IP)	*				78p
Philadelphia	PHL	52 (IC)	*	*p	*		
Phoenix	PHX	26 (S)		52			
Pittsburgh	PIT	52 (IP)	*	*	*		63p
Portland	PDX	36 (DP)		52	*		

Table 3-3. Potential Siting of New IFR Approach Procedures and Their Associated IFR Arrival Capacity[1] (continued)

Airport Location	Airport Code	Current Best IFR Arrival Capacity (App Procedure)[2]	New Approach Procedures[3]				
			Dependent Parallel	Independent Parallel	CRDA	TERPS+3	Triples
Portland	PWM	26 (S)			34		
Providence	PVD	26 (S)	36		*		
Raleigh-Durham	RDU	36 (DP)		*	*		63p
Reno	RNO	26 (S)			34		
Richmond	RIC	26 (S)				52	
Rochester	ROC	26 (S)			*	52	
Sacramento	SMF	52 (IP)					
Salt Lake City	SLC	36 (DP)		*		*	63p
San Antonio	SAT	26 (S)			*	52	
San Diego	SAN	26 (S)					
San Francisco	SFO	26 (S)			34		
San Jose	SJC	26 (S)					
San Juan	SJU	26 (S)				52	
Santa Ana	SNA	26 (S)					
Sarasota-Bradenton	SRQ	26 (S)					
Savannah	SAV	26 (S)		52p	*		
Seattle-Tacoma	SEA	26 (S)	36p				
Spokane	GEG	26 (S)		52p			
St. Louis	STL	26 (S)	*		*	52	
Syracuse	SYR	26 (S)		52p	*		
Tampa	TPA	52 (IP)		*	*	*	
Tucson	TUS	26 (S)					
Tulsa	TUL	52 (IP)			*		78p
Washington	DCA	26 (S)			34		
Washington	IAD	52 (IP)				*	78p
West Palm Beach	PBI	26 (S)			34		
Wichita	ICT	52 (IP)				*	
Windsor Locks	BDL	26 (S)					

1. Generic (not airport-specific) capacities are used here to provide a basis of comparison only. These capacities, derived through the FAA Airfield Capacity Model, use a standard aircraft mix. Generally, runways not suitable for commercial operations were not considered. Also, factors such as winds and noise constraints are not taken into account.

2. Current Best Approach Procedure Abbreviations:
   S - Single runway
   DP - Dependent Parallel runways
   IP - Independent Parallel runways
   IC - Independent Converging runways

- An Asterisk (*) indicates proposed new approach procedures applicable at the airport in question; however, it also means that either the current best procedure, or another proposed approach procedure (under new rules), provides equal or better arrival capacity.
- A number indicates the hourly arrival capacity provided by a new approach procedure, when such capacity is larger than the one provided by other procedures (current or new), applicable at the airport in question.
- A “p” indicates that the approach procedure will be applicable if and when planned runway construction/extensions take place at the airport in question.

3.2 Airspace Planning

Airspace design involves extensive coordination between air traffic controllers and airspace planners. Several efforts are underway to improve the efficiency of the airspace system. Airspace Capacity Design Projects are either completed or underway at 20 major areas in the United States. Annual flight delay savings from the individual projects range into thousands of hours and millions of dollars.

A variety of computer models have been used to analyze a broad spectrum of capacity solutions. Since 1986, the System Capacity and Requirements Office has been applying the SIMMOD model to large scale airspace redesign issues. The first such project was an analysis of the Boston ARTCC in support of the expansion of that facility's airspace. That study identified benefits ranging from $23 million to $123 million depending on demand projections. Similar studies were initiated at the Los Angeles, Fort Worth, and Chicago ARTCCs studying issues as diverse as resectorization, special use airspace restrictions, new routings, complete airspace redesigns, and new runway construction. Computer modeling has been used to quantify delay, travel time, capacity, sector loading, and aircraft operating cost impacts of the proposed solutions.

The most productive solutions have generally involved additional runways. For example, the construction of even one new runway in Chicago would result in savings of up to $54 million per year without considering any increase in traffic. On the other hand, efficiencies have been identified in airspace design. For instance, depending on demand projections, the restructuring of Los Angeles Center airspace will save between $23 million and $41 million per year assuming no growth in runway capacity.

At Dallas-Ft. Worth, effects of the Metroplex plan were studied both with and without new runway construction. Results indicated an immediate savings of $13 million per year resulting from airspace changes alone. By the year 2010, the total plan would have saved a cumulative $5.2 billion in delay; $1.7 billion attributable to airspace, and $3.5 billion to the construction of two new air carrier runways. This demonstrates the "system" nature of the delay problem.

The FAA plans to institutionalize these activities by expanding the capability of its Technical Center in Atlantic City, N.J. Under the guidance of a policy level work group in Washington, the Technical Center, and soon the National Simulation Laboratory, will provide the FAA with the in-house resources to conduct studies using a variety of models.

During 1991, studies were completed at the Kansas City, Houston, and Oakland ARTCCs. What follows are excerpts from

Airspace Capacity Design Projects are either completed or underway at 20 major areas in the United States.

A study of the Boston ARTCC identified benefits ranging from $23 million to $123 million.

The construction of one new runway in Chicago would result in savings of up to $54 million per year.

The restructuring of Los Angeles Center airspace will save between $23 million and $41 million per year.

Studies of the effects of the Metroplex plan on Dallas-Ft. Worth have shown that an immediate savings of $13 million per year are possible from airspace changes alone.

those analyses. It should be noted that the FAA considers alternatives based on technical feasibility. No analysis of political or social considerations are reflected in this data.

3.2.1 Kansas City Area Airspace

The objective of the Kansas City Airspace Capacity Project was to evaluate operational alternatives in the St. Louis Terminal Radar Approach Control (TRACON), Kansas City TRACON and Kansas City ARTCC airspaces, aimed at increasing capacity, reducing delay, and improving the overall efficiency of air traffic operations. To meet this objective, three major simulation analyses were conducted. The first involved evaluating delay and capacity impacts at Lambert-St. Louis Airport associated with relocating arrival fixes based on a four cornerpost VOR system, implementing dual arrival routes over the cornerposts, and developing new departure routes. Table 3-4 illustrates the projected cost and delay savings associated with these changes through 1995.

Table 3-4. Delay and Cost Savings for Lambert-St. Louis Traffic for Alternative Improvement Options

	Improvement Option			Daily Delay Savings in Hours			
Demand Year	Airspace Routes	Flows over Arrival Fixes	Departure Gates	VFR Weather	IFR Weather	Average Day*	Annual Cost Savings**
1990 (base)	Old	Dual	Old	2	0	2	$1 Million
	New	Dual	New	14	0	12	$7 Million
1992 (+8%)	Old	Dual	Old	10	0	9	$5 Million
	New	Dual	New	31	0	26	$15 Million
1995 (+22%)	Old	Dual	Old	23	0	20	$12 Million
	New	Dual	New	137	0	116	$68 Million

* Delay on the average day is calculated based on VFR and IFR conditions occurring 85% and 15% of the time, respectively.

** Marginal aircraft operating cost savings are based on flight costs of $1,600 per hour.

The second analysis evaluated proposed airport/airspace improvements designed to increase capacity at Kansas City International Airport. Improvements included adding an independent parallel north-south runway, establishing a four cornerpost VOR system, realigning airspace, and re-routing traffic around the Truman Military Operations Area (MOA).

The third analysis entailed an evaluation of modifications of Kansas City ARTCC traffic flows to align with the St. Louis and

Kansas City TRACON arrival and departure changes, re-routing of overflight traffic based on specific destination criteria, and raising the ceiling on low altitude sectors from FL230 to FL270. After final analysis in March 1991, Kansas City ARTCC has decided to leave the low altitude sector ceilings at FL230. However, they now have re-stratified the four high altitude sectors which work arrivals and departures into and out of Chicago. The sectors, located in central Illinois and northeastern Missouri, have been redesigned to include two high altitude sectors from FL240 to FL330 (primarily designated for arrivals and departures into and out of Chicago, St. Louis, and Kansas City) and two sectors overlying those from FL350 and above (primarily designated for coast to coast overtraffic). The initial realignment of high altitude sectors was effective in August of 1991. All phases of the resectorization plan should be in effect by March 1, 1992.

3.2.2 Houston/Austin Airspace

To meet the Houston/Austin Airspace Capacity Project objective of quantitatively evaluating the capacity and delay impacts of operational alternatives in the Houston and Fort Worth Centers and in the Austin TRACON, two simulation analyses were conducted. The first involved evaluating the capacity gains and delay reductions that would result from construction of the new Austin airport at Manor, Texas, including redesigning airspace structures, routings, and procedures in the Austin TRACON. The second analysis involved analyzing the impacts of potential re-routing of specific Austin bound traffic from the east coast through the Fort Worth Center instead of via the present routing through the Houston Center.

Delay and cost savings were estimated for these changes under the assumptions that Austin would become a hub airport and that it would not become a hub airport. These results are summarized in Tables 3-5 and 3-6, respectively, for the years 1990 through 2010. The results show substantial benefits under either scenario, but the cumulative cost savings under the hub scenario are more than six times as large as under the non-hub scenario, $2,795 million versus $423 million.

Table 3-5. Delay and Cost Savings for the New Austin Airport/Airspace System at Hub Traffic Demand Levels

Traffic Demand*	Average Daily Delay Savings**	Annual Cost Savings***
1990	11 Hours	$7 Million
2000	122 Hours	$71 Million
2010	700 Hours	$409 Million
	Cumulative Savings 1990 through 2010	$2795 Million

* Traffic demand for Austin is based upon hub scenario forecast levels. Other traffic is assumed to grow at a rate of 4% per annum.

** Delay on the average day is calculated based on VFR and IFR conditions occurring 88% and 12% of the time, respectively.

*** Marginal aircraft operating cost savings based on flight costs of $1,600 per hour.

Table 3-6. Delay and Cost Savings for the New Austin Airport/Airspace System at Non-Hub Traffic Demand Levels

Traffic Demand*	Average Daily Delay Savings**	Annual Cost Savings***
1990	11 Hours	$7 Million
2000	32 Hours	$19 Million
2010	70 Hours	$41 Million
	Cumulative Savings 1990 through 2010	$423 Million

* Traffic demand for Austin is based upon non-hub scenario forecast levels. Other traffic is assumed to grow at a rate of 4% per annum.

** Delay on the average day is calculated based on VFR and IFR conditions occurring 88% and 12% of the time, respectively.

*** Marginal aircraft operating cost savings based on flight costs of $1,600 per hour.

3.2.3 Oakland Area

The following issues were addressed by the Oakland Airspace Project:

- An evaluation of airspace realignment and operational alternatives to alleviate the complexity and saturation problems associated with Oakland ARTCC Sector II.
- An evaluation of air traffic operations under the proposed Northern California Metroplex Control Facility (MCF) airspace redesign, which would consolidate operations in Bay, Sacramento, Stockton, and Travis approach controls.
- An analysis of the impacts on civilian traffic of proposed expansion of special use airspace in the Fallon, Nevada area, which includes Nellis Air Force Base training areas.
- An analysis of the impacts of alternative routes and procedures to alleviate noise problems in the Sacramento area.

The cost savings associated with various combinations of these changes together with the proposed extension of San Jose (SJC) Runway 30R are summarized in Table 3-7 for the years 1991 through 2000.

Table 3-7. Annual Aircraft Operating Cost Savings for MCF Airspace and SJC Runway Options

Improvement Option		Annual Cost Savings*		
Airspace	SJC Rwy 30R	1991	1995	2000
New	Existing	$2.1 M	$4.7 M	$13.7 M
Old	Extended	$3.9 M	$7.2 M	$20.7 M
New	Extended	$7.0 M	$15.6 M	$45.9 M

* Based on marginal aircraft operating costs of $1,600 per hour.

3.2.4 Studies in Progress

Currently, the FAA System Capacity Office is in the process of studying Washington, Cleveland, New York, and Jacksonville Centers and is supporting work in the New York and Atlanta Centers.